

# Assessment in Science and Mathematics

Educators and others use assessment for a variety of reasons. Such reasons include the desire to measure student learning, to identify areas of difficulty for individual students, to provide opportunity for students to apply their problem solving skills, to plan instructional strategies, and to provide evidence of the effectiveness or impact of an educational program. No single assessment instrument can accomplish all of these tasks. Multiple instruments are needed.

It should be said at the outset that a comprehensive portrait of achievement by American students in science and mathematics requires input from all levels. These include the classroom, school, state, nation, and the world. Cooperation, therefore, between constituencies at all levels is essential.

Student assessment at each level brings with it a unique set of issues, complexities, and reasons for assessing students. Nonetheless, some principles apply to student assessment at any level. First, effective assessment should begin with identifying the purpose and context in which the assessment is to be used, the type of information sought, and the use to which the information will be put. Assessment instruments designed for specific purposes should vary; most often, an assessment program should include the application of a variety of assessment instruments.

Second, an assessment program at every level should be aligned with rigorous and challenging content standards of what students should know and be able to do. In this document, standards include content and performance standards, benchmarks, and principles or guidelines that provide a vision of what we want students at the elementary and secondary levels to know and be able to do in mathematics and science. The standards may be developed at the local, district, state, and national levels. At each level, these standards should be developed with the strong support and involvement of content experts and key constituencies.

Assessments at the national level may not be consistent with all aspects of every state's content standards, since standards in different states may not be consistent with each other. Similarly, international assessments may not be aligned with all national

goals among different nations. Nevertheless, assessments at the national and international levels should support and align with these goals when possible and where appropriate.

In addition to these two fundamental principles, an assessment program at each level should:

- \* assess student knowledge and understanding of science and mathematics in ways that are more complex and demanding than traditional tests, by including the assessment of higher order thinking skills and problem-solving ability;
- \* be valid, reliable, and fair;
- \* be based on knowledge of how students learn and develop;
- \* be implemented in such a way that each assessment instrument is used and interpreted only for the purpose for which it was intended and in a context where that purpose is clear to all groups involved in the assessment and use of its results;
- \* use assessment results in the process of improving instruction strategies and curriculum development; and
- \* promote equity by providing each student optimal opportunity to demonstrate scientific and mathematical knowledge and skills.

## ASSESSMENT FOR STUDENTS

When appropriately and effectively applied, student assessment measures what we value. Many different methods of assessment should be used to assure that all students -- those with various abilities, backgrounds, and levels of English language proficiency -- have ample opportunity to be challenged by assessment. Moreover, assessment should be an integral part of the learning process, not the end result. An assessment program for students should:

- \* be coherent and comprehensive;
- \* be equitable and engage all students;
- \* be integrated with instructional strategies and curriculum materials to promote effective student learning; and
- \* provide information that will help yield valid inferences about students' learning.



*From Dr. Berg's Class  
Coventry Middle School  
Coventry, Rhode Island  
Eighth Grade Activity*

### **Performance Assessment in the Science Classroom**

*Performance assessments are processes whereby students use knowledge, skills and competencies to construct responses to problems. In performance assessments, students are doing, telling about, writing about, and visually representing what they know, often in the context of a real-life situation. These types of assessment provide important information about student understanding that cannot be obtained, for example, from a multiple-choice test.*

*Early in the year, Dr. Berg used a performance assessment to pre-test his students knowledge of, familiarity and comfort with some of the techniques and tools scientists use. The room was set with fourteen individual stations which the students moved through, completing a two-minute task at each station. The tasks were process based -- the students were required to draw, measure, weigh, read and create charts and graphs, and interpret information. At one station students demonstrated their understanding by calibrating and using a balance correctly.*

*The findings of this pre-test will allow Dr. Berg to see how well the students have mastered the tools and techniques necessary to fully participate in the learning and exploration of science. The assessment also gave the students a CLEAR indication of the many types of knowledge, skills and competencies they will be required to master and use if they are going to be successful students.*

## TEACHERS AND ASSESSMENT

Teachers must be actively involved in the entire assessment process if learning, instruction, and assessment are to become integrated in the classroom. Teachers need training, time and support to be able to:

- \* understand the variety of assessment designs and strategies as well as the strengths, applications, and limitations of each assessment instrument;
- \* have effective instruments for each assessment purpose;
- \* assess students informally and frequently;
- \* make sound judgments of individual student achievement based on the results of assessments; and
- \* report student progress to students, parents, and administrators in a timely and meaningful way.

## SCHOOLS, COMMUNITIES, AND ASSESSMENT

A school uses student assessment in a variety of ways. Some student assessments are geared to measuring individual student achievement. Others are used to evaluate the effectiveness of the school's programs in light of local, regional, or state expectations. It is important to report on the effectiveness of the school's programs to students, parents, teachers, school boards, other policymakers, and the community at large. Because statistical data and changes in assessment techniques which are left unexplained often can be confusing, such aspects of the assessment process should be open to review and scrutiny.

To provide effective assessments of the school's programs for the community and clear understanding of the results of assessment, the school should:

- \* align classroom student assessment with adopted school curricula and educational objectives for students;
- \* make clear to both students and parents what assessment instruments are measuring when they are applied;
- \* facilitate public, and in particular, parental understanding of the variety of assessment techniques being used in the schools; and

\* ensure that student progress is reported to parents, and that the school's performance is reported to the community in an open and meaningful manner.

Educational reform revolves around three central issues; what students should learn, how they should be taught, and how progress should be measured.

Curriculum, instruction, and assessment must mutually support one another in the educational process, with each serving common goals and high standards. Assessment, in particular, must cease to be an independent function designed principally for the efficiency and economy of administration. Instead, educators should use it to measure all facets of curriculum and instruction and consider its contribution to students' learning.

In science and mathematics, the new and broader aims of assessment can be captured in three broad educational principles, as defined by the Mathematical Science Education Board's publication entitled Measuring What Counts:

1. The Content Principle: Assessment should reflect the sciences and mathematics that are most important for students to learn.
2. The Learning Principle: Assessment should support good instructional practices and enhance learning.
3. The Equity Principle: Assessment should support every student's opportunity to learn important science and mathematics.

These three principles place special demands on assessment reform at the classroom, school, district, state, and national levels if assessment is to be interwoven into the fabric of educational reform. An effective assessment should provide information that can be used to improve students' access to scientific and mathematical knowledge and to help each student prepare to function effectively in our complex and changing society.

#### MEASURING ACHIEVEMENT OF THE SCIENCE CURRICULUM BENCHMARKS

Changes in science and mathematics curricula and instructional goals, as set out in the benchmarks of the science framework, require changes in assessment, if real reform is to occur. Assessment can no longer simply mean that teachers administer norm-referenced tests or end-of-the-unit tests; but rather, a system of assessments intimately related to instructional goals must be created. Such a system can include some familiar types of tests but there is also a need for much greater reliance on performance assessment strategies and portfolios.

We must, of course, assess student knowledge, but we also need to assess student understanding through application of their knowledge. This can be done by implementing assessments that require students to use their knowledge. With our growing understanding of how people learn and our recognition that each student has multiple intelligences and preferred learning styles, our instruction and assessment strategies must be varied to assure that all students can learn and achieve at high levels. Equity in learning opportunities and assessments require this.

## PERFORMANCE ASSESSMENTS

Performance assessments are processes whereby students use knowledge, skills and competencies to construct responses to problems. Responses are rated according to preestablished scoring guides (rubrics). In performance assessments, students are doing, telling about, writing about, and visually representing what they know, often in the context of a real-life situation. Performance assessment methods can take many forms, including demonstrations, displays, speeches, videotapes, artifacts created with paper and pencil, observations, open-ended responses and oral responses.

These types of assessments provide important information about student understanding that cannot be obtained, for example, from a multiple-choice test. They may be implemented to a whole class at the same time, as one would test with traditional approaches, or they may be completed by individuals or groups of students as appropriate within the instructional process. The assessment purpose, for example, assigning a grade, deciding whether to provide additional learning experiences for a given concept to some or all of the students or providing a statewide picture of student achievement would determine when and how an assessment is given.

Effective performance assessments can do all of the following:

- \* balance content and cognitive processes;
- \* allow students to demonstrate what they know, as opposed to what they don't know;
- \* provide opportunities to see real-life connections in their classroom instruction; and
- \* emphasize how an answer is obtained or what an answer means, in addition to the answer itself.

Performance tasks provide students with a situation to investigate. The teacher facilitates and observes the processes and then examines the results/products to determine, using a structured scoring guide (rubric), what the students actually know and can do. Such an assessment may involve the use of

manipulative materials or equipment, and may involve an instructional component. Students are required to be active rather than passive, and the investigation portion may be accomplished individually, in a group, or through a combination of group and individual work.

Open-ended questions provide for multiple solutions and thus allow students to respond in a variety of ways. There may be one answer or many answers and many ways to arrive at an answer. Responses can be verbal, written, graphic/pictorial or a combination. They can be evaluated on how the solution was reached and on clarity of presentation in addition to the answer.

For a more thorough discussion of performance tasks and their grading through rubrics, please refer to pages 9-10 of the Mathematics and Science Performance Assessment Handbook for Teachers and Administrators, available from the Office of Outcomes and Assessments at RIDE. Pages 10-14 discuss a plan for professional development that could easily be adapted to the science classroom.

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